Nectar Robbing in *Epacris impressa* (Epacridaceae) by the Recently Introduced Bumblebee *Bombus terrestris* (Apidae) in Tasmania

Andrew B. Hingston[1,2] and Peter B. McQuillan[1]

Abstract

The frequency of nectar robbing by *Bombus terrestris* (L.) was compared between two populations of Common Heath *Epacris impressa* Labill. in southern Tasmania. Robbing was more frequent in the population with longer corollas, resulting in most open flowers being pierced. As these corolla tubes were shorter than most Victorian flowers of the same species, it is likely that *B. terrestris* would also rob flowers of *E. impressa* in Victoria if it crosses Bass Strait.
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Introduction

The Large Earth Bumblebee *Bombus terrestris* (L.) was first recorded in Australia in the Hobart suburb of Battery Point on 19 February 1992 (Semmens *et al.* 1993). It has subsequently spread rapidly across Tasmania (Semmens 1996), but has not yet been recorded from the Australian mainland. In southern Tasmania it occurs at high densities in a wide variety of native vegetation types including coastal heath, dry sclerophyll forest, and subalpine shrubbery up to an altitude of 1100 m. Within these habitats it forages on a wide range of plants (polylecty), being recorded from 66 native species from 21 families between September 1996 and June 1997 (Hingston and McQuillan in press), raising concerns of adverse ecological consequences.

One concern involves the well known tendency for this species to obtain nectar from flowers with tubular corollas by piercing them (e.g. Hawkins 1961; Morrison 1961; Holm 1966; Barrow and Pickard 1984; Donovan and Macfarlane 1984; O'Toole and Raw 1991). Studies on other plants have found that robbing is more prevalent in bumblebee workers and drones than in the larger queens (Carpenter 1979; Fussell 1992).

The most common plant with tubular flowers in Tasmania is Common Heath *Epacris impressa* Labill. (Epacridaceae). This species was the second most frequently visited (after Manuka *Leptospermum scoparium* J.R. & G. Forst.) by *B. terrestris* during 1996-97 near Hobart (Hingston and McQuillan *in press*), with nectar being accessed both through the corolla throat and by piercing the corolla.

We were investigating whether the relationship between bumblebee tongue length and flower corolla tube length was related to the frequency of nectar robbing at *E. impressa* in two populations near Hobart by *B. terrestris*. Subsequent comparison of corolla lengths between *E. impressa* in Victoria and these populations allowed speculation on the likelihood of the flowers of *E. impressa* in Victoria being robbed by *B. terrestris* if the bee were to cross Bass Strait.

Methods

Bumblebees were observed while foraging on *E. impressa* at two areas in southern Tasmania on 13 days between January and April 1997, and the numbers accessing nectar legitimately (via the corolla throat) and by robbing (piercing the corolla tube) were recorded. As tongue length is proportional to body size within a *B. terrestris* colony (Dafni and Shmida 1996), body lengths were used as an indication of tongue lengths. Measurements were made using a 30 cm ruler with 1 mm graduations on random samples of workers and drones captured at both sites between 20 December and 7 February 1997. A random sample of the corolla tube lengths of flowers was measured by the same method in early March at both sites, with only one flower being sampled per plant.

[1] Department of Geography and Environmental Studies, University of Tasmania, GPO Box 252-78, Hobart, Tasmania 7001.
[2] Corresponding author. Phone (03) 6226 7455, fax. (03) 6226 2989,
email hingston@postoffice.sandybay.utas.edu.au

The study sites were: Coffee Creek, consisting of heathy Black Peppermint *Eucalyptus amygdalina* Labill. coastal forest on Triassic sandstone at an altitude of 10–50 m; and Hobart from Mt Nelson to Waterworks Reserve, where dry sclerophyll forest grew on Jurassic dolerite at an altitude of 150–250 m.

Results

Most workers and drones, and all but one of the queens, foraging on *E. impressa* at Coffee Creek accessed nectar legitimately (Table 1). However at Hobart, workers and drones usually robbed flowers. Only four queens were observed foraging on *E. impressa* at Hobart, with all of these also piercing the corolla (Table 1). These differences in foraging behaviour between the two populations were statistically significant for workers and drones ($\chi^2 = 150.81$, $p < 0.001$) and for queens ($\chi^2 = 24.69$, $p < 0.001$).

Bombus terrestris appeared responsible for all corolla piercing, as no other animals were observed robbing flowers at either site. The high proportion of individuals robbing flowers at Hobart resulted in virtually all corollas being pierced by the end of February, raising the possibility of a major impact on this population.

The distributions of worker and drone body lengths at both sites differed significantly from these expected from populations with normal distributions ($p = 0.0064$, Kolmogorov-Smirnov Normality Test). Consequently, the non-parametric Mann-Whitney Rank Sum Test was employed to compare body lengths between populations. This test demonstrated that the workers and drones at Hobart were significantly shorter than those at Coffee Creek ($T = 5938.0$, $p < 0.0001$) (Table 2).

The distributions of corolla lengths at both sites also differed significantly from those expected from populations with normal distributions ($p < 0.0001$, Kolmogorov-Smirnov Normality Test). Corollas were significantly longer at Hobart than at Coffee Creek ($T = 6177.0$, $p < 0.0001$, Mann-Whitney Rank Sum Test) (Table 2). However, the corollas at Hobart were still shorter than those in many Victorian populations (Table 3).

Discussion

The discovery of more frequent nectar robbing at Hobart, where *E. impressa* corollas were longer and *B. terrestris* workers and drones were smaller, is consistent with the hypothesis of robbing occurring when nectar cannot be reached via the throats of tubular flowers (Willmer and Corbet 1981).

If *B. terrestris* becomes established in Victoria it is very likely that nectar robbing will also be the predominant foraging technique there because all red, all pink, and some white corollas in Victoria are as long or longer than those at Hobart (Stace and Fripp 1977). Hence, if they cross Bass Strait, *B. terrestris* can be expected to rob a large proportion of Victorian *E. impressa*, providing that their flight periods and flowering phenologies overlap.

Table 1. Numbers of *Bombus terrestris* observed accessing *Epacris impressa* nectar via the corolla throat and by piercing the corolla.

Castes	Sites	Robbing	Legitimate	% Robbing
Workers and drones	Hobart	112	20	84.8
	Coffee Creek	18	133	11.9
Queens	Hobart	4	0	100.0
	Coffee Creek	1	27	3.6

Table 2. Length distributions for workers and drones of *B. terrestris* between 20 December 1996 and 7 February 1997, and corolla tubes of *E. impressa* during the first week of March 1997, at Hobart and Coffee Creek.

Variable	Site	n	25% quartile	Median	75% quartile	Range (mm)
Workers & drones	Hobart	104	15.0	16.5	18.0	11-21
	Coffee Ck	58	17.0	18.0	20.0	14-21
Corollas	Hobart	60	10.5	11.0	13.0	9-15
	Coffee Ck	86	9.0	9.5	10.0	6-13

Table 3. Ranges of corolla lengths (mm) of *Epacris impressa* from various regions. Victorian data from Stace and Fripp (1977).

Site	Colour	Range
Hobart	pink	9.0-15.0
Coffee Ck	pink and white	6.0-13.0
Victoria	white	8.6-13.2
W. Victoria	pink	11.0-16.0
E. Victoria	pink	15.0-22.0
Victoria	scarlet	17.0-20.0
Grampians (var. *grandiflora)*	red and white	12.0-17.0

This nectar robbing may influence the reproductive success of *E. impressa*. Because individuals involved in robbing other species usually do not contact the anthers and stigmas (Morrison 1961; Holm 1966; Donovan and Macfarlane 1984; O'Toole and Raw 1991) (but see Macior 1966), seed-set may be adversely affected through lack of pollen transfer between flowers (Dafni and Shmida 1996). Although *Bombus affinis* Cresson queens pollinate Columbine *Aquilegia canadensis* L. flowers which they rob, because they land on the anthers and stigma prior to piercing the nectar spur (Macior 1966), this is unlikely to occur when *B. terrestris* robs *E. impressa* because the anthers are within the corolla tube.

Seed-set may also decrease as the result of reduced numbers of visits by legitimate visitors in response to lower nectar levels following robbing (Pyke 1990; Dafni and Shmida 1996). However a plant's reproductive organs are not damaged by robbing, allowing pollination to occur through subsequent legitimate nectar and/or pollen collection (Donovan and Macfarlane 1984). Indeed, it has been proposed that the reduction in nectar levels due to robbing may force legitimate nectarivores to visit more flowers per unit time, thereby increasing seed-set (Heinrich and Raven 1972).

However, some visitors which would otherwise access the nectar via the corolla throat may become secondary robbers by extracting nectar through the holes made by *B. terrestris* (Morrison 1961; Holm 1966; Barrow and Pickard 1984; O'Toole and Raw 1991). Although this would be expected to have adverse effects on pollination one such case in Red Clover actually enhanced seed-set (Hawkins 1961). Holes in corollas resulting from robbing (mostly by *B. terrestris*) allowed access to nectar by European Honey Bees *Apis mellifera* L., which attracted more of them to the crop. *Apis mellifera* also gathered pollen from Red Clover, and in so doing transferred it between flowers of this obligate outcrossing species, thereby increasing seed-set (Hawkins 1961).

It is thus difficult to predict the impact of nectar robbing on the fecundity of *E. impressa*, although any impact may eventually alter plant community structure (Aizen and Feinsinger 1994). Consequently, further research is necessary to determine how the overall reproductive success of *E. impressa* is affected by the nectar robbing of *B. terrestris* ahead of attempts to introduce *B. terrestris* formally to other Australian states as a consequence of the active promotion of its agricultural potential (e.g. Semmens 1995). As *B. terrestris* moves shorter distances between flowers while foraging than do smaller bees (Herrera 1990), its effect on outcrossing rates in native plant species is also worthy of investigation.

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Rabbit Control

Rabbits are a continuing problem for farmers, local government, park managers. For groups involved in revegetation and habitat restoration, the costs of tree guards and replacing eaten plants can be considerable

In a recent issue of Indigenotes, we saw information on a new method to help control rabbit numbers. Known as 'Rid-a-Rabbit, it uses LP gas to kill rabbits. The gas is released down the rabbit burrow and then ignited with an electronic probe. The resultant rush of ignited gas through the burrow burns up the available oxygen and the rabbits die in about 45–120 seconds from lack of oxygen.

This unit is small and portable and allows easy access to difficult-to-reach areas, and would appear ideal as a simple, effective, environmentally friendly and humane alternative to fumigation. Current users include New South Wales National Parks and Wildlife Service, Landcare Groups in Victoria and a number of farmers.

The unit is Australian made and invented, and costs around $2450.00 to buy and operating costs are about two cents a rabbit hole, which is a cheap method when money is tight.

Further information can be obtained from Rid-a-Rabbit Marketing, PO Box 423 Bulleen, Victoria 3105. Telephone (03) 9841 4507.

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